TNRCC TECHNICAL GUIDANCE
PETROLEUM STORAGE TANK DIVISION

SUBJECT: Remedial Action Plans

PURPOSE

This document is intended to assist owners and operators of leaking product storage tanks (LPSTs) in Texas. When there has been a release from a product storage tank resulting in contaminant levels which exceed site cleanup goals, a technology for site remediation must be selected. A remedial action plan (RAP) should be proposed which provides documentation and justification for the most appropriate remedial technology. A written directive from the Texas Natural Resource Conservation Commission (TNRCC) is not required to initiate emergency abatement activities or product recovery operations, as immediate response is required per the Texas Administrative Code, Chapter 334.

When remediation is necessary, a detailed RAP describing the two (2) remedial alternatives which incorporate the technologies most feasible for the site should be prepared. The RAP should be based upon the results of the completed comprehensive site assessment and should address the necessary remediation of the existing contamination at the site to achieve the final cleanup objectives. The viability and costs of the two RAPs should be compared and an indication of the preferred RAP should be provided and justified.

TECHNOLOGY SELECTION CRITERIA

A number of factors must be taken into account prior to the selection of the most effective and efficient remedial method for site cleanup. Selection of the best remedial technologies will be dictated by the nature and location of the release, the site soil and lithology types, hydrogeological conditions, and the required degree of remediation. Items of concern include, but are not limited to:

- State and federal regulatory compliance requirements;
- Human health and safety risks;
- Viable remedial technologies; and
- Cost.

BACKGROUND DATA REQUIREMENTS

The following items should be completed **prior** to the development of a RAP. The data should assist in the development of a RAP for soil and/or groundwater contamination, and should include:

- A visual and physical survey of the site to observe any possible pathways for contaminant migration (utility lines and trenches, surface water drainages, or other potential receptors) or other potential sources of contamination, such as other former or active gasoline stations. All potential receptors should be investigated for hydrocarbon impacts.
- An inspection of records of inventory control and reconciliation and past tank tests and repair records. Investigate the historical use of property including type of products stored (presently and previously).
- A site map drawn **to scale** which portrays the actual facility, the entire UST/AST system (including tanks, piping, dispensers, and observation wells), buildings, adjacent roads, subsurface utilities, surface drainages, borings/

printed on recycled paper using soy-based ink

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monitoring wells, excavations, a North arrow, a bar scale, and a legend. The map should include any recreational area, residence, or other structure not occupied or used solely by the owner or operator of the LPST site located within 100 feet of the site.

- A water well survey to determine the exact locations and status of any water wells within 500 feet of the site.
- A water well inventory map which portrays the site location of all water wells located within a 1/2–mile radius of the site. The inventory should include a compilation of the completion intervals for each well.
- A characterization of the site geology and hydrogeology which includes specific descriptions of the stratigraphy, structural features, the water-bearing formations encountered during drilling and any other major or minor aquifers present (including approximate depth(s), thickness(es), hydraulic gradient, groundwater flow direction(s), production capabilities, water quality, and present uses).
- A delineation of the vertical and horizontal extent of the soil and/or groundwater contamination. Groundwater contamination includes the presence of phase-separated product and any dissolved contaminants (dissolved-phase contamination).
- If groundwater is impacted, a groundwater sample from an upgradient monitoring well should be collected and analyzed for total dissolved solids (TDS) to determine the groundwater quality.
- A groundwater gradient map which includes, on a site map drawn to scale, all existing monitor wells, plotted groundwater elevation measurements, labelled equipotential contours, arrow(s) indicating predominant flow path(s), date of measurement, a North arrow, a bar scale, and a legend.

REMEDIAL TECHNOLOGIES AND TESTING REQUIREMENTS

The following is a partial list of available remediation technologies along with a brief description of each technology and the associated testing requirements. This list references only a portion of the remedial technologies currently available for LPST cleanups and in no way promotes any one technology over another.

Remedial Technologies

- Excavation - The process by which affected soils are removed from the subsurface.
- Soil Vapor Extraction - The application of a vacuum to remove volatile contaminants from the vadose zone and to provide oxygen to enhance natural biodegradation.
- Air Sparging (subsurface) - The injection of air into groundwater to volatilize dissolved-phase contaminants and to provide oxygen to enhance natural biodegradation; to be applied only if soil vapor extraction will be utilized to remove all vapors produced.
- Groundwater Extraction and Treatment - Also referred to as “Pump and Treat”; the removal of contaminated groundwater from the subsurface and subsequent treatment of the water using surface equipment to remove the contaminants.
- Thermal Treatment - The process of heating soils so that contaminants with low boiling points will vaporize and, consequently, separate from the soil. The vaporized contaminants are collected and treated, typically by an air emissions treatment system.
- Bioremediation - The stimulation of naturally-occurring (indigenous) microorganisms or the addition of cultured (exogenous) microorganisms to contaminated soils or groundwater to degrade organic contaminants into less toxic or nontoxic compounds.

Testing Requirements

Aquifer tests, pilot tests or feasibility tests are required to demonstrate the viability of certain technologies and to assist in the design of the actual system.

- Soil Vapor Extraction (SVE) - A soil vapor extraction pilot test should be performed to determine the feasibility of using SVE as a remedial method. The radius of influence induced by the vapor extraction system operating at an opti-

mum flow rate should be calculated. The quantity of hydrocarbon vapors extracted should be measured to determine the contaminant removal rate and the requirement for vapor treatment prior to discharge and registered under Standard Exemption 68 or permitted. This applies to any air emissions systems.

- Air Sparging (Subsurface or In-Situ) - An air sparging pilot test should be performed at several flow rates to observe the effects of air injection rate on vapor concentrations, pressures, groundwater elevations, and dissolved oxygen concentrations. If air sparging is recommended, a pilot test should also be conducted to determine the optimal soil vapor extraction rate required to effectively recover all vapors generated by air injection. A proposal for air sparging can only be approved if SVE is also proposed and if documentation is submitted to demonstrate that the injection of air will **not** induce vapor accumulations and/or potential vapor impacts to buildings or subsurface utilities and that it will not result in the spread of the contaminant plume.
- Groundwater Extraction & Treatment - A rising head slug or bail down test and/or an aquifer pumping test should be performed to determine the aquifer characteristics. The aquifer's hydraulic conductivity (K), transmissivity (T), and storativity (S) should be calculated. A determination of the radius of influence, capture zone, and a sustainable pumping rate should also be made. For any assumed or estimated values, justification and references should be provided. **If a groundwater remediation system is to be installed, an aquifer pumping test will be required to demonstrate feasibility and determine appropriate recovery well positions.**
- Bioremediation - Bioremediation techniques can be grouped into two general categories: 1)*in-situ* techniques, which treat contaminants in place, without removing the contaminated soil or water, and 2)*ex-situ* techniques, which typically treat soil or water aboveground in a vessel or reactor. A bioremediation feasibility test should be performed to determine the feasibility of using*in-situ* or*ex-situ* bioremediation as a remedial method. A feasibility test should include the identification of the naturally-occurring microorganisms capable of degrading the contaminants, and the toxicity of the impacted media to determine if the organisms can survive. Typically, nutrients and oxygen are applied to stimulate the naturally-occurring microbes to degrade the contaminants at a faster rate than would occur if not stimulated.

LIMITING SOIL CHARACTERISTICS FOR REMEDIAL TECHNOLOGY EVALUATION

The following is a summary of the limiting characteristics for specific remedial technologies[1].

Remedial Technology	Process Limiting Characteristics
Soil Vapor Extraction	Applicable only to volatile organics with significant vapor pressures >1mm Hg
	Low soil permeability inhibits air movement
	Soil hydraulic conductivity >1E-8 cm/sec required
	Depth to groundwater > 20 feet recommended
	High moisture content inhibits air movement
	High organic matter content inhibits contaminant removal
Bioremediation (*in-situ*)	Applicable only to specific organics
	Hydraulic conductivity >1E-4 cm/sec preferred to transport nutrients
	Lower permeability layers difficult to remediate
	Temperature 15-45°C required
	Moisture content 40-80% of that at -1/3 bars tension preferred
	pH 4.5 - 8.5 required
	Presence of microbes required
	Minimum 10% air-filled porosity required for aeration
Thermal Treatment	Applicable only to organics
	Soil moisture content affects handling and heating requirements
	Particle size affects feeding and residuals
	pH <5 and >11 causes corrosion

[1] *Ground-Water Issue*, EPA/540/4-91/003, March 1991.

TESTING REQUIREMENTS, AIR MONITORING REQUIREMENTS, AND WASTEWATER DISCHARGE REQUIREMENTS

The following is a summary of testing requirements, air monitoring requirements, and wastewater discharge requirements for specific remedial technologies.

Remedial Technology	Media	Testing Requirement	Monitor Air Emission	Wastewater Discharge
Excavation	Soil	1 sample per 50 cy of excavated soil	Yes	No
Soil vapor extraction	Soil	SVE pilot test	Yes	No
Bioremediation (in-situ)	Soil	Bioremediation feasibility test	Yes	No
Bioremediation (ex-situ)	Soil	Bioremediation feasibility test	Yes	No
Thermal treatment	Soil	Sampling: 1/50 cy before treatment 1/50 cy after treatment (TPH) 1/250 cy after treatment (BTEX)	Yes	No
Groundwater extraction with SVE	Soil & groundwater	Aquifer test & SVE pilot test	Yes	Yes
SVE & air sparging	Soil & groundwater	SVE & air sparge pilot test	Yes	No
Groundwater extraction	Groundwater	Aquifer test	No	Yes
Bioremediation (in-situ)	Groundwater	Bioremediation feasibility test	No	Yes
Bioremediation (ex-situ)	Groundwater	Bioremediation feasibility test & aquifer test	No	Yes

DISCHARGE PERMIT REQUIREMENTS

The following is a summary of the required permits and monitoring requirements for specific discharge methods.

Discharge Method	Required Permit	Monitoring Requirements
Atmosphere	TNRCC permit or permit exemption 68	Determined by permit or exemption to permit
Storm sewer (surface)	TNRCC, Subchapter H, Chapter 321 and NPDES permit (or general permit when available)	Weekly or as required by permit
Sanitary sewer	City permit	Determined by operator of POTW
Infiltration gallery	Register Class V reinjection wells with TNRCC	As required by TNRCC (no permit)
Reinjection well	Register Class V reinjection wells with TNRCC	As required by TNRCC (no permit)
Disposal well	Railroad Commission and/or TNRCC authorization	None

TNRCC, Permits or Standard Exemptions 68 – Contact the TNRCC Air Permitting Division at 512/239-1230.

TNRCC, TAC 321, Subchapter H – Contact the Watershed Management Permitting Section of the TNRCC at 512/239-4554.

National Pollutant Discharge Elimination System (NPDES) Permit – Contact the EPA, Region VI at 214/655-7180.

TNRCC, Class V Reinjection Well – Contact the Groundwater Assessment Section of the TNRCC Water Planning and Assessment Division at (512) 239-4514.

Disposal Well Use for PST Waste – Prior approval must be obtained from the TNRCC and Railroad Commission (RRC). Contact the RRC, Underground Injection Control at (512) 463-6790 to verify that a well is permitted for wastewater disposal.

At LPST sites where pump and treat technology is utilized to either control plume migration or is effectively combined with an additional remedial technology (i.e., soil vapor extraction), options for discharge of the treated groundwater should be considered. One option is to discharge the treated groundwater to surface water (typically via storm sewers) in accordance with the registration procedures specified in 30 TAC Chapter 321. Another option is to discharge the treated groundwater to a wastewater treatment plant (with concurrence from the plant owner). However, these options may not be available at all sites. In areas where groundwater recharge is not adequate to restore withdrawals from the aquifer, the removal of large quantities of groundwater and discharge to the surface is not the most desirable option due to the significant depletion of the groundwater resource. In these situations, it may be more appropriate to reinject treated groundwater into a Class V injection well or infiltration gallery. This option has limitations, such as restrictions for access to offsite properties outside the plume boundaries, but it has the advantages of possibly being less costly and serving to restore the groundwater resource.

With approval from the RPR coordinator and registration of the injection well(s) with the Watershed Management Division, groundwater reinjection is typically allowed under the following conditions:

1. The reinjected groundwater is treated to contaminant levels below the site-specific cleanup goals.
2. The injection well(s) is/are located outside the contaminant plume boundary and the injection well(s) is/are surrounded by monitor wells in order to detect any plume migration in a direction other than the normal groundwater flow direction.
3. Should plume migration be detected in another direction, injection must cease until a determination of appropriate actions can be made. This may necessitate the disposal/discharge by another means and therefore, the RP should plan for this contingency.
4. The quantity of injected groundwater must be accounted for in the design of the pumping system and in the design of the injection wells. Site-specific hydrologic parameters should be considered and testing should be conducted when necessary to demonstrate the feasibility of using reinjection as a disposal option.

RAP REPORT REQUIREMENTS

Remedial action plans will vary according to the type of corrective action proposed; however, all RAPs should present enough design detail to permit evaluation of their effectiveness. Unless a proposed technology will address multiple medias, a separate discussion should be prepared for each of the following topics:

- Soil contamination.
- Surface water contamination.
- Groundwater contamination.

Remedial action plans should include the following information and be generally structured as follows:

I. Chronology of Events

- The dates and a brief description of all significant events that have occurred since a problem was suspected at the facility. Commence with the first date a problem was suspected and continue through the most recent activity described in the RAP report.

II. Aquifer and/or Vadose Zone Tests

- Test results for slug tests, pumping test, soil vapor extraction and/or air sparge pilot tests.
- Test results for biofeasibility test.
- Summary of the field data collected with data calculations and plots.

III. Remedial Alternatives

- Remedial alternative methodologies under consideration.
- Discussion of the advantages and disadvantages of each remedial alternative.
- Graph of time vs costs for each alternative.
- Discussion of the remedial option chosen and why the chosen alternative was selected.
- Practical discussion of how the remedial option chosen will affect subsurface conditions (groundwater-level changes, enhanced bioremediation, etc.).
- RAP objectives.

IV. Cleanup Goals

- Soil cleanup levels.
- Groundwater cleanup levels.
- Cleanup time calculations.
- Estimated total amount of time required for cleanup.
- Method(s) for determining site cleanup levels.

V. Remedial System Design and Specification

- Proposed remediation system with a description of the specific equipment to be used, including the proposed locations, design, and required construction for all elements.
- Remediation system plan view map and schematic design drawing (**not as-built drawings**).
- Provide projected implementation schedules for each stage of remediation (eg., permits, system installation, startup, etc.).

VI. Permit Requirements

- Discussion of local, state, and federal permits or other authorization necessary to install and operate the remedial system.

VII. Discharge Requirements

- Discussion of the method(s) of storage, treatment and/or disposal for excavated soils.
- Discussion of the method(s) of storage, treatment and/or disposal for groundwater effluent.
- Discussion of the method(s) of treatment for air emissions/effluent.

VIII. Monitoring and Maintenance

- Remedial progress monitoring (type and recommended frequency).

- Discharge monitoring.
- Proposed monitoring and reporting plan.
- System performance evaluation.
- System maintenance.

IX. Closure Plan

- Closure Plan that includes the procedures which will be used to shut down and abandon/remove all remedial system components.
- Monitoring well plugging proposal.
- Confirmation soil boring proposal.

X. Cost Estimates

- Costs estimates for project with breakdown of capital, operation & maintenance costs, and closure costs. The estimates should include the cost of the initial installation, yearly operational and maintenance costs, closure costs, and the projected total costs to achieve the cleanup goals.
- Feasibility of leasing equipment vs purchasing equipment.

XI. Appendices

- Equipment brochures from vendors.
- Field test data.

Remedial action plan reports should conform to the format set forth in the TNRCC publication entitled *Reporting Guidelines For LPST Cleanups In Texas* (PST 93-01).

REMEDIAL ACTION PLAN IMPLEMENTATION

Following the implementation of a remedial action plan, a *Field Activity Report (FAR)* (form TNRCC-0017) should be prepared and submitted to the TNRCC. The FAR should provide a brief description of the completed remedial actions such as the installation, performance, operation, and maintenance of the remedial system.

In general, the following information should be included in a FAR to document the implementation of a RAP:

- A description of the **completed** remedial actions, including the locations, design, and required construction for all elements of the remedial system.
- As-built construction details of the entire remediation system.
- A discussion and tables of operating parameters of the remedial system, such as pumping rates, drawdowns, product recovery rates, air flow rates, and pressure measurements.
- A discussion of the method of treatment, recycling and/or disposal for vapors, groundwater effluent, recovered product, or excavated soil.
- A discussion of the system's performance and effectiveness.
- Actual cost to date versus projected cost at time of proposal.
- Photographic documentation of the installed remediation system.

REMEDIAL ACTION PLAN ADDENDUM

A RAP addendum is required when the TNRCC issues a directive to an owner and/or operator requesting that a RAP addendum be prepared. An addendum may consist of modifications or additions to the original RAP submitted to the TNRCC. If a RAP addendum is requested, a FAR should be prepared and submitted. The FAR should provide a reason for the addendum and the proposed changes with the projected costs.

Should you have any questions regarding this document, contact the TNRCC coordinator assigned to your particular case or contact the Responsible Party Remediation Section of the PST Division at 512/239-2200.